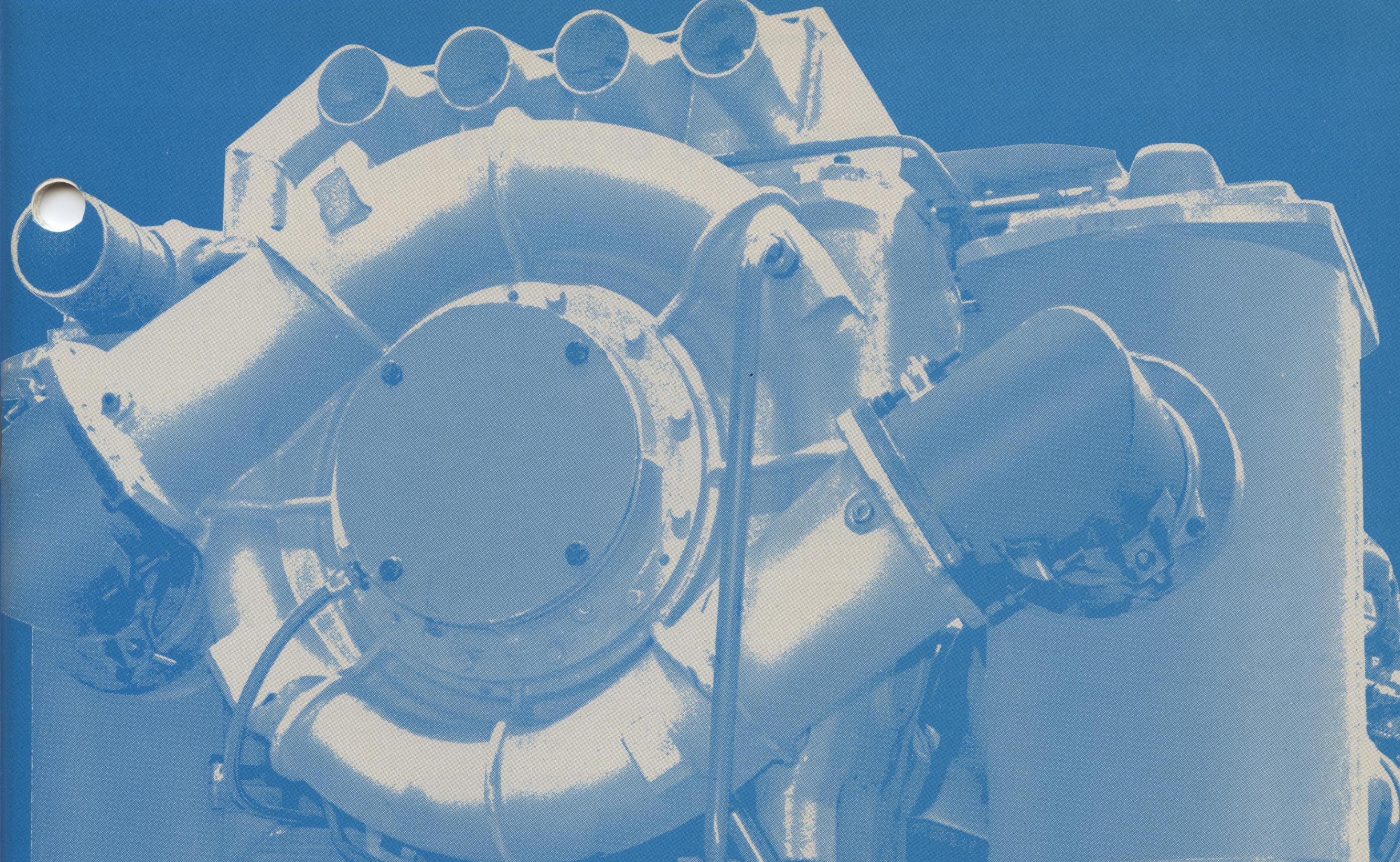

DIESEL ENGINE BEARINGS

a guide to inspection and analysis

GENERAL ELECTRIC

A special note of thanks

. . . to Thomas J. Milliren, Manager of Warranty Administration, whose expertise in the area of diesel engine bearings proved vital throughout the preparation of this publication.

During the past several years, Tom has added to a wealth of experience in bearing inspection and analysis. Through well prepared and documented presentations, he has shared this knowledge with customer personnel at the GE Locomotive Schools and at railroad shops.

Working with customers this way, Tom has developed keen insight into information which is most useful to those who inspect and analyze condition of the bearings. That information, together with additional recommendations from Tom, forms the background of this practical guide on bearings used in GE diesel engines.

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Introduction – a short course in bearing construction and location

This brochure has been prepared as a guide for those persons who make decisions as to the performance and replacement of main and connecting rod bearings.

Analyzing the condition of these bearings requires a certain amount of background knowledge and experience. Misinterpreting the appearance of various bearing surface conditions may lead to needless replacement expenses or, when bearing distress is not recognized, severe engine damage.

To aid in the analysis of surface appearance, the pages that follow illustrate actual bearings removed from General Electric diesel engines. Bearing conditions are discussed and recommendations furnished.

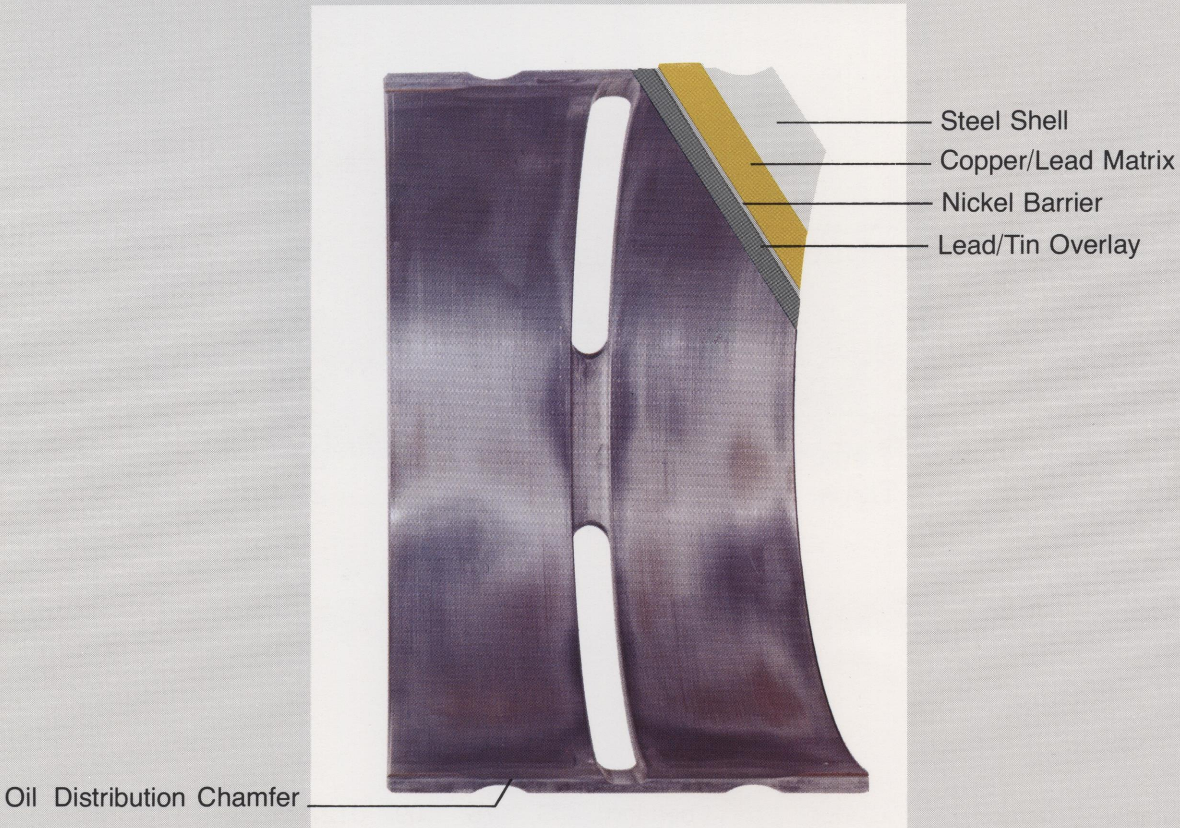
The publication can thus serve as a useful guide when making an extremely important evaluation: the high cost of bearing-related failures versus the relatively low expense for timely and proper maintenance to the bearings and their supporting systems.

Precision-fitted steel shells with copper/lead matrix and lead/tin overlay

Main and connecting rod bearings used in the General Electric diesel engine are precision-fitted steel shells with bearing material applied to the running surface as shown in Figure 1.

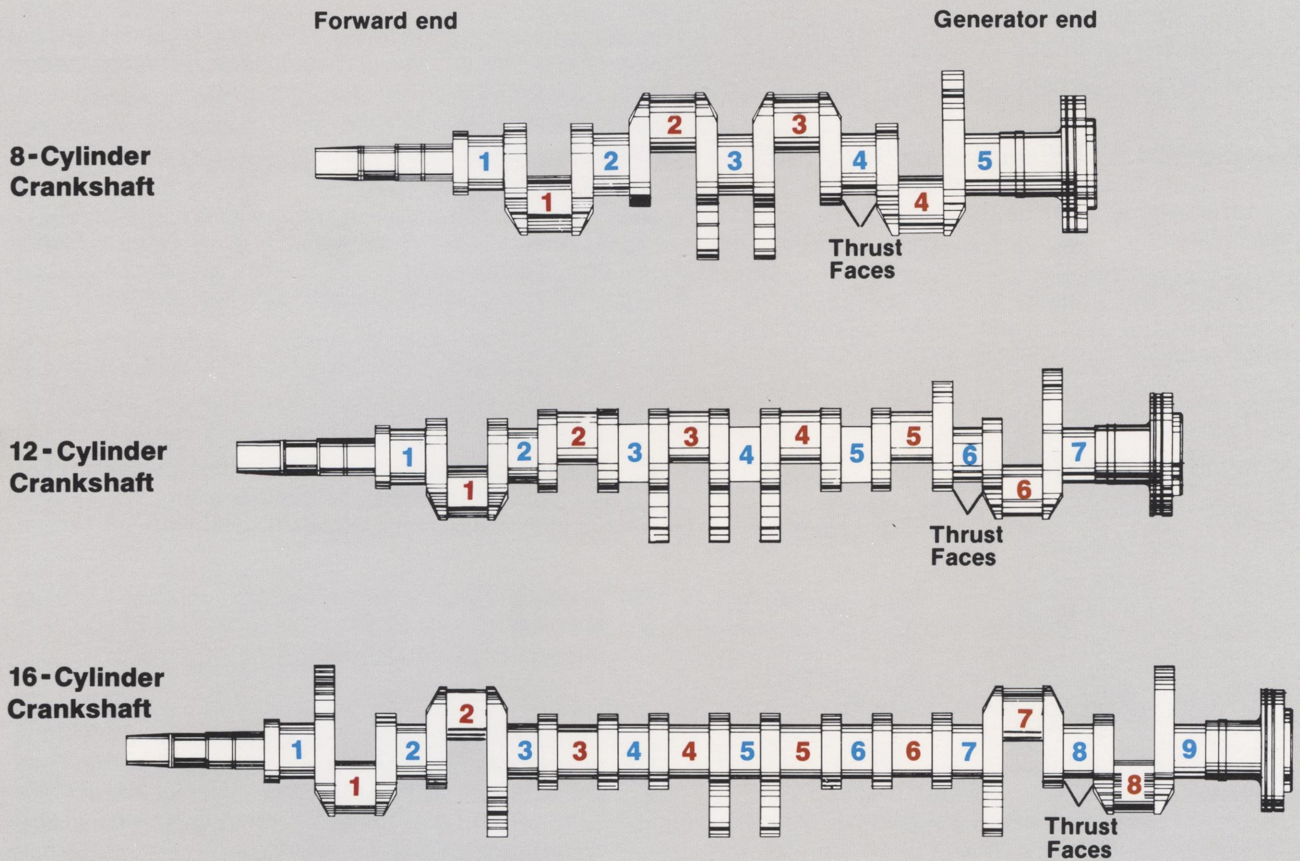
Basic bearing material is a copper/lead matrix specially arranged to provide maximum strength and to resist acid corrosion. The nickel barrier adds strength to the bearing surface and further protects against corrosion.

The lead/tin overlay allows the bearing to accommodate slight initial load distribution adjustments during break-in. It also minimizes bearing and journal damage from small abrasive particles in the oil system.



Location on all engine models

Location of the bearings on 8, 12, and 16-cylinder engines is shown below. Numbers begin at the forward end of the crankshaft (turbocharger end of the engine). Thrust bearings are at the Number 4, 6, or 8 main journals on the respective crankshafts.


Forward end
Generator end
8-Cylinder Crankshaft
1 2 3 4 5
1 2 3 4
Thrust Faces
12-Cylinder Crankshaft
1 2 3 4 5 6 7
1 2 3 4 5 6
Thrust Faces
16-Cylinder Crankshaft
1 2 3 4 5 6 7 8 9
1 2 3 4 5 6 7 8
Thrust Faces

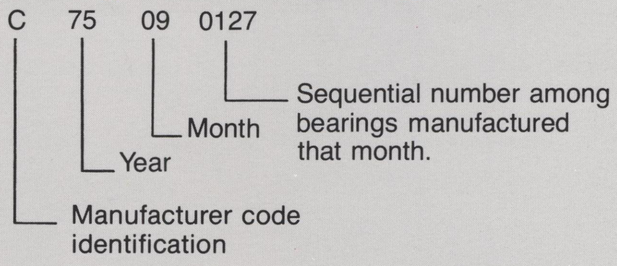
🟦 Main bearing locations

🟥 Connecting rod bearing locations

The serial number — an aid in estimating service life and age

A serial number is stamped on the edge of each bearing shell along with catalog and General Electric drawing numbers. As illustrated in the example, this serial number includes identification of the manufacturer, date of manufacture (both year and month), and the sequential number among bearings produced during the specific month.

When records are not available, service life or age of a bearing can be approximated by referring to this serial number coding.


C 75 09 0127
Sequential number among bearings manufactured that month.
Month
Year
Manufacturer code identification

When to inspect bearings

A thorough inspection of the main and connecting rod bearings is required whenever any of the following occurs:

- serious fuel dilution or water contamination of the lubricating oil.
- failure of a lubricating oil pump, pump drive, or system.
- a major engine parts failure which could contaminate the lube oil system with large quantities of foreign material and perhaps with water.
- an engine overspeed that permits operation at speeds above the normal trip setting. Engine speeds in the 1400-rpm range and above for even a few seconds can damage the bearings.
- normal life expectancy has been reached based on time and mileage. As a general rule, main and connecting rod bearings should be replaced when one-third of the total area of the loaded half shows bronze. (Loaded half is lower for main bearings, upper for rods.)
- the engine is repeatedly cranked or manually forced to run without lube oil pressure.

In making the bearing inspection, any combination of ten basic conditions will likely be encountered. Photographic examples of these conditions are illustrated on the following pages and comprise the major portion of this publication. Along with each example are probable causes and recommended action.

Ten basic bearing conditions

1 Normal wear.

2 Scored, grooved, or scratched — caused by foreign abrasive material in the oil supply or oil passages.

3 Wiped or seized, showing thermal distress — caused by loss of lubrication, mechanical misalignment, overloading, dry starts, or a hot-running engine. Engine overspeed will cause overloading and resultant wiping.

4 Material fatigue — caused by bearing overloads, poor fit, dirt imprints, or overly extended service.

5 Shell fretting — caused by a loose or poor bearing fit in the bore.

6 Surface erosion — caused by fluctuating oil pressure in certain areas of the bearing.

7 Physical damage — caused by improper handling and application, incorrect crankshaft thrust control, or a bent connecting rod.

8 Corrosion — caused by poor control of the lube oil acid properties. This condition is rarely found on a General Electric diesel engine when recommended lubricating oil and oil control procedures are utilized. No photographs are available.

9 Water damaged — caused by water contamination of the lubricating oil.

10 Surface discoloration without indicated distress — colors can vary from dark gray to yellowish gold, brown, and blue. This is primarily related to materials in the lubricating oil and has no effect on bearing life.

Probable location of bearing failure

Bearing failures caused by low oil viscosity or engine overspeed commonly affect certain bearings first (determined by their loading characteristics).

Main bearings near the center of the crankshaft and thrust bearings will generally be the first to experience distress when viscosity has been seriously reduced by fuel dilution or overheated oil. These bearing locations are as follows:

Model FDL-16 diesel engine: Number 4, 5, and 6 main bearings and both thrust bearings (at Number 8 position).

Model FDL-12 diesel engine: Number 3, 4, and 5 main bearings and both thrust bearings (at Number 6 position).

Model FDL-8 diesel engine: Number 2, 3, and 4 main bearings and both thrust bearings (at Number 4 position).

When severe engine overspeed has occurred, thrust bearings and connecting rod bearings are generally the first to be damaged.

Bearing failures are likely at *any or all* locations when caused by a large quantity of foreign material in the oil, overextended service, water contamination, or when cranked or operated without oil pressure. No predominant pattern has been observed in these cases.

Inspection sequence

Whenever any serious bearing distress is observed, or suspected, based on oil analysis or crankcase inspection, main and connecting rod bearings should be inspected in accordance with the sequence below.

Any disturbance of bearings in the engine involves an element of risk. Therefore, only qualified personnel, equipped with the proper tooling, should perform bearing inspection and replacement.

Before starting disassembly, inspect the crankcase for indication of overheat discoloration and metallic particles in the side clearance area of connecting rod, main, and thrust bearings. Also, look for metallic particles on crankcase ledges and other surfaces.

Then remove and examine both thrust bearings. Inspect thrust faces on the crankshaft. Drop bearing caps at any location which shows visible distress. Check those bearings and journal surfaces for damage.

In any case, check one or more center main bearings with the bearing cap lowered (consult above reference to location of these bearings).

Also inspect one or more connecting rod bearings with both the rod cap and upper shell removed.

When serious bearing distress is found, but the crankshaft remains serviceable, inspect all main and connecting rod bearings. Replace as necessary.

Guidelines for replacing

Replacing the bearings requires strict adherence to this set of guidelines.

If a worn main or connecting rod bearing is removed — for any reason — from its original fit in cap, main frame, or rod, it should not be reapplied. During application and service, a bearing becomes fitted to a specific location and the soft lead/tin overlay helps compensate for minor load readjustments. When a used bearing shell is reapplied, poor alignment and seating is likely to lead to failure.

Lower main bearings (loaded half) can be inspected by dropping the cap nuts and cap just far enough to view the bearing surface. Removing the nuts from the stud bolts is not necessary. Cap and bearing can then be restored with minimum risk of bearing failure. However, the upper half of connecting rod bearings (loaded half) cannot be inspected without removal. If removed for any reason, they should be replaced.

When renewing a lower main bearing, inspect the discarded shell. If any bronze is showing, adjacent lower mains should also be renewed. This is necessary to maintain crankshaft alignment and to assure proper bearing load distribution.

Connecting rod bearings should always be replaced in sets (upper and lower halves) to assure reliable performance.

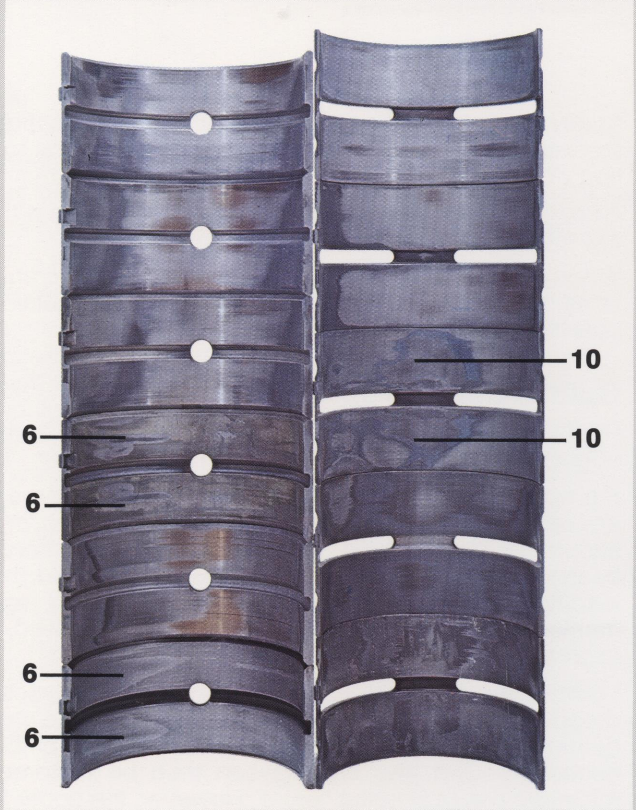
When installing main and connecting rod bearings, strive for the best possible metal-to-metal fit between bore and bearing. Before assembling the bearing, dress off any metal fretting, roughness, or upsets in the bores and split line surfaces. Properly fit bearing locating tabs in their slots; keep bearing ends flush with split lines. Closely observe the stretch and torque values on main and connecting rod cap bolts respectively during assembly. This assures that proper clamping force is applied to the bearing shells.

Observing surface appearance: cause and recommended action

Introductory section of this brochure provided summary information on bearing construction, location in the engine, the inspection sequence, and replacement guidelines for those making the decision.

Surface appearance of actual bearings removed from General Electric diesel engines will now be analyzed. With these examples, maintainers have a ready reference to conditions they can expect to observe, the probable cause of bearing distress when it is recognized, and the recommended action.

Reference numbers refer to the basic conditions described on page 6.



(Typical Bearings, Not A Set)

Normal wear patterns (serviceable)

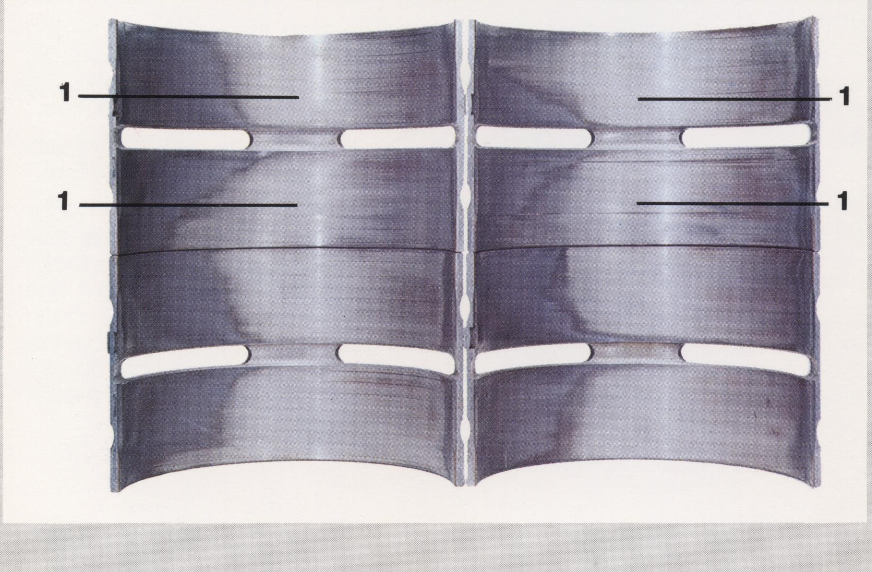
Observation:

6 Cavitation erosion of lead/tin surface overlay — no effect on bearing performance.

10 Blue coloration caused by lubricating oil additives — no effect on bearing performance.

Action:

None — no effect on bearing performance.



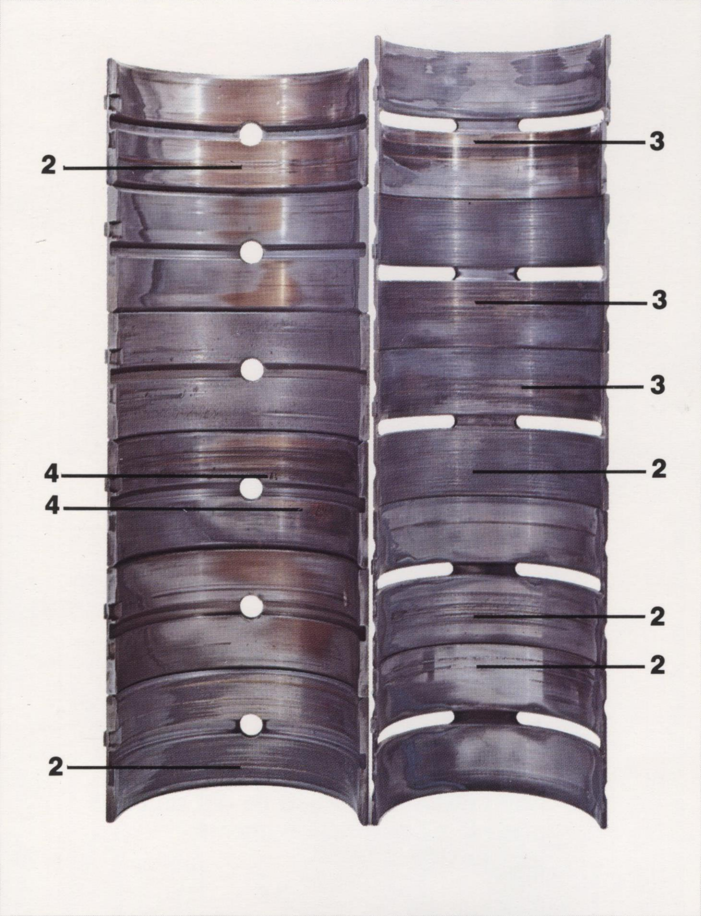
Normal connecting rod bearing wear patterns — upper halves (serviceable)

Observation:

1 Initial wear through overlay.

Action:

None — normal wear.



(Typical Bearings, Not A Set)

Distressed bearings (not serviceable)

Observation:

2 Severe dirt scoring.

3 Wiped due to oil film failure.

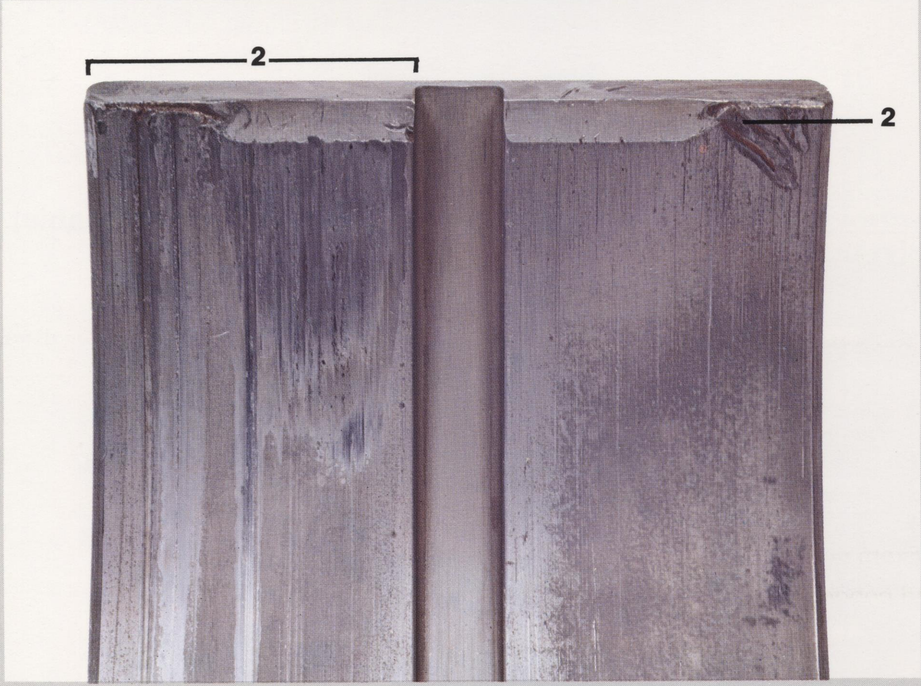
4 Bearing metal fatigue.

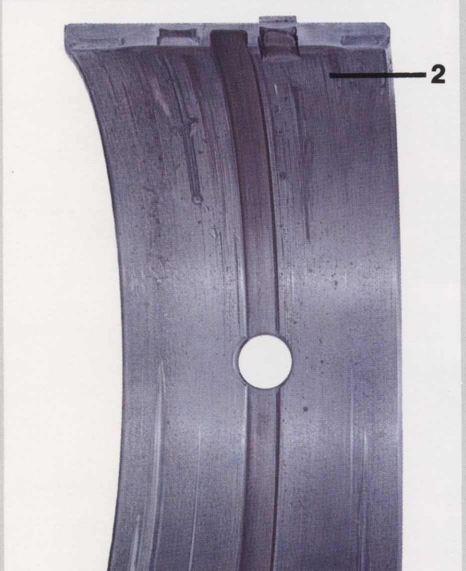
Action:

Investigate source of dirt.

Investigate cause of lubrication failure.

Replace all main and connecting rod bearings.





Grooved or scratched bearings (not serviceable)

Observation:

2 Bearing grooving caused by dirt particles trapped in oil distribution chamfer.

Action:

Investigate source of dirt.

Replace bearing.

Wiped bearings (not serviceable)

Observation:

2 Severe dirt scoring.

3 Heat distressed (wiped) area with thermal fracture of bearing metal. Caused by loss of oil film.

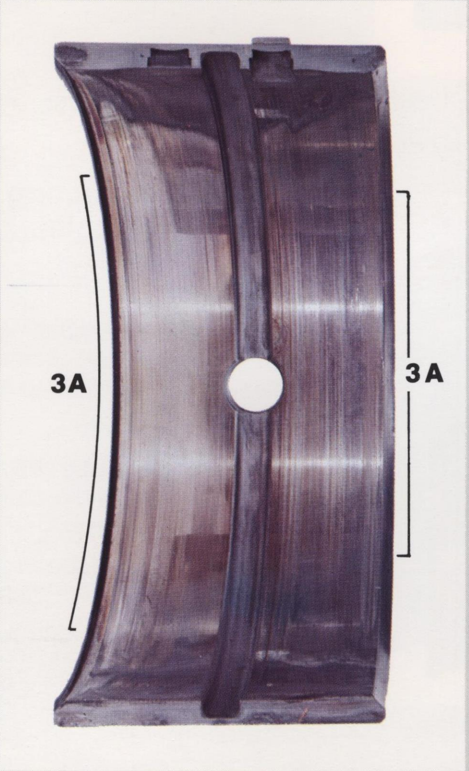
3A Heat distressed (wiped) area similar to above. Wear pattern indicates a hot-running engine or severe fuel dilution.

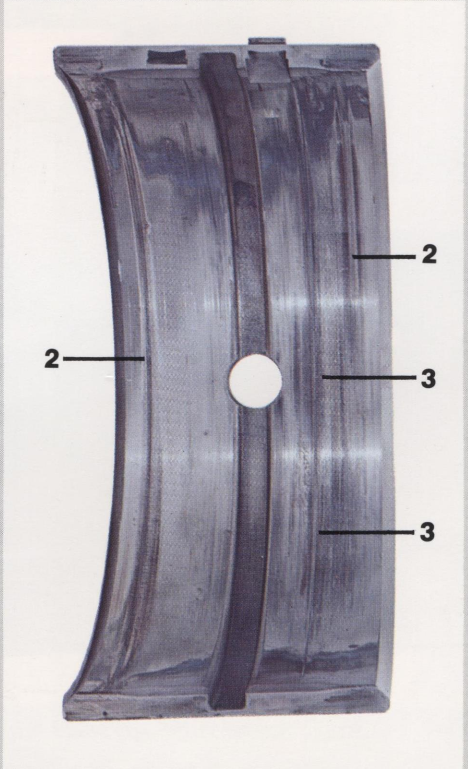
Action:

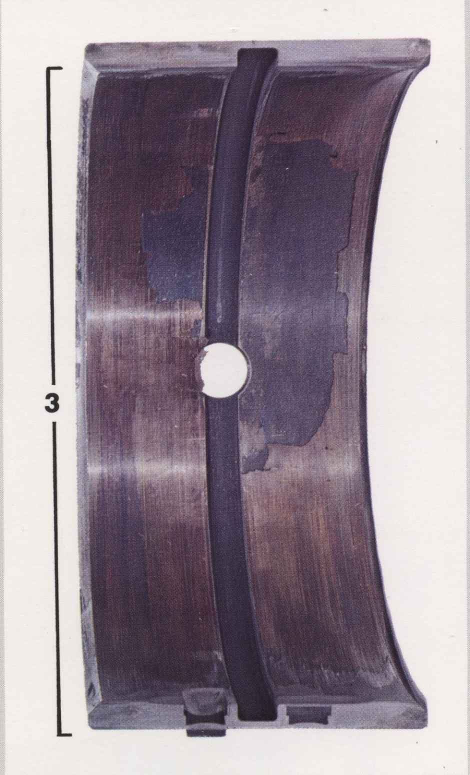
Check lubricating oil condition.

Investigate lube system cooling and filtration.

Renew all main and connecting rod bearings.







Overheated main bearing caused by oil film failure (not serviceable)

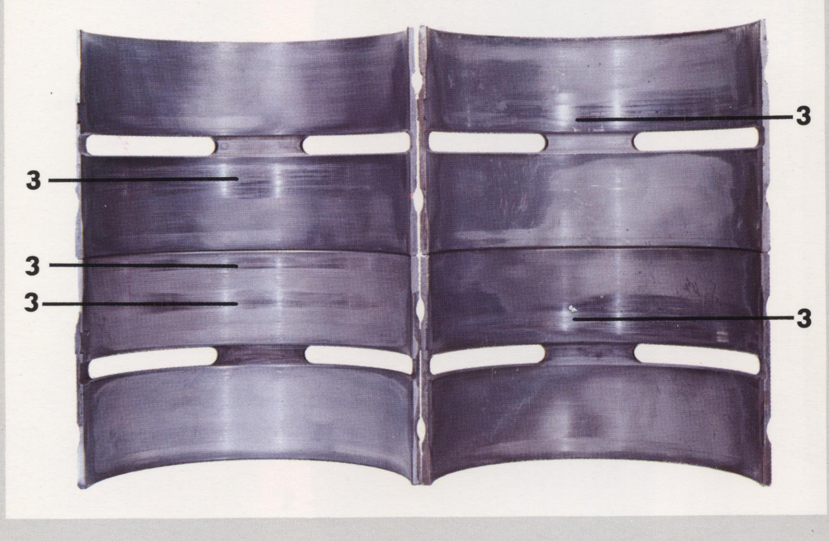
Observation:

3 Thermal destruction and loss of bearing material caused by seized journal.

Action:

Investigate lubricating oil and system for cause of failure.

Examine crankshaft journals for serviceability.



Wiped connecting rod bearings (not serviceable)

Observation:

3 Typical distress resulting from cranking engine without oil pressure, severe fuel dilution, or overheated lube oil.

Action:

Check lube oil, lube oil system, and cooling system for possible cause of bearing distress.

Spot check main bearings and thrust bearings for similar distress.

Renew all connecting rod bearings.

Distressed main bearings (not serviceable)

Observation:

1 Extensive bearing wear.

2 Dirt scratches and grooves.

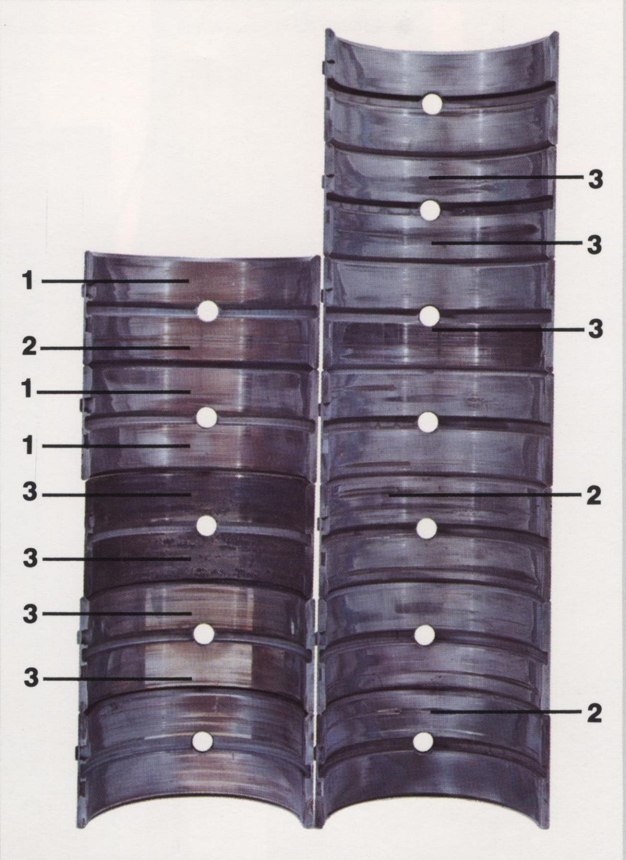
3 Wiped or seized.

Action:

Check lube oil, lube oil system, and cooling system for possible cause of bearing distress.

Review bearing renewal periods.

Renew bearings.



(Typical Bearings, Not A Set)

Distressed main bearing (not serviceable)

Observation:

2 Dirt grooves and scratches.

3 Wiping, showing thermal distress of bearing material.

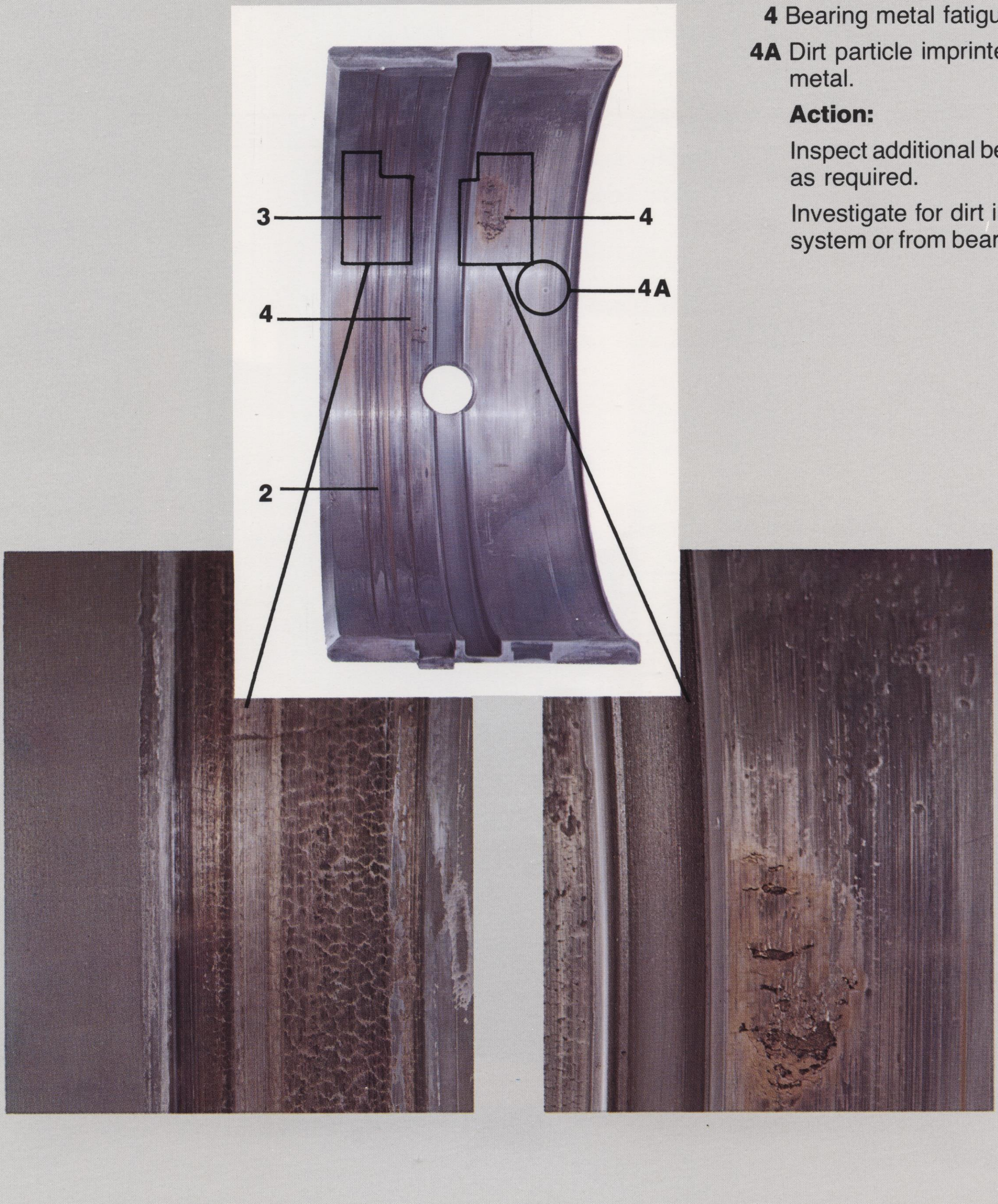
4 Bearing metal fatigue and erosion.

4A Dirt particle imprinted in bearing metal.

Action:

Inspect additional bearings. Renew as required.

Investigate for dirt in lubricating oil system or from bearing application.



Metal fatigue — connecting rod bearing (not serviceable)

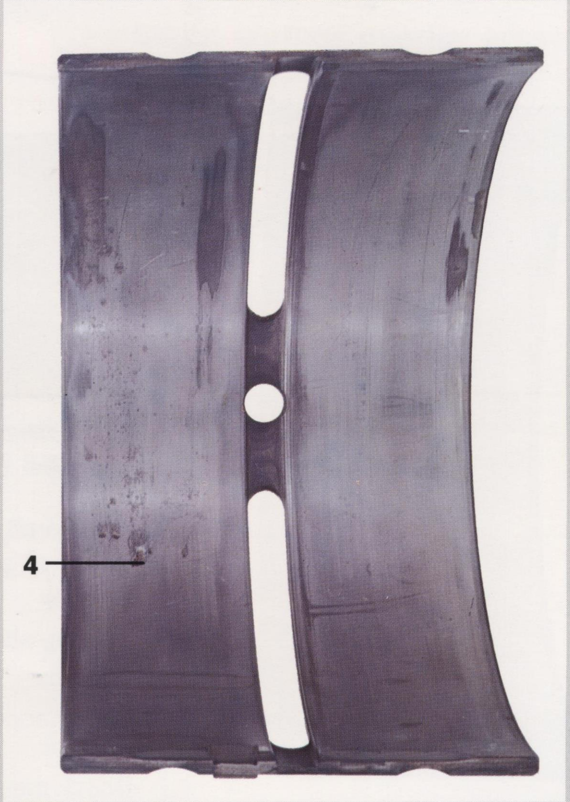
Observation:

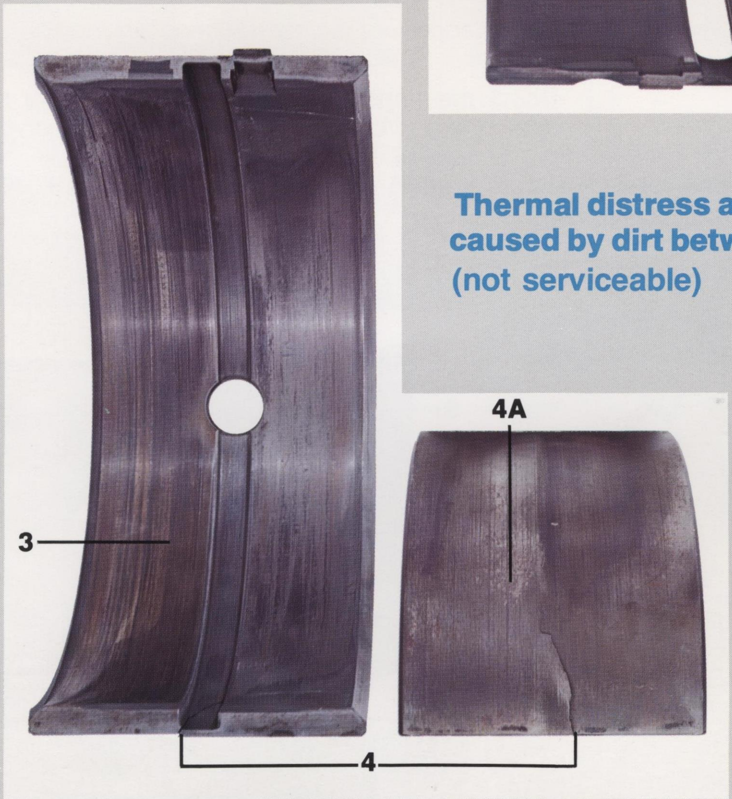
4 Material fatigue, causing surface pitting.

Action:

Inspect additional bearings. Renew as required.

Inspect one or two main bearings.





Backside

Thermal distress and fatigue caused by dirt between shell and bore (not serviceable)

Observation:

3 Wiping and thermal distress caused by localized surface overloading.

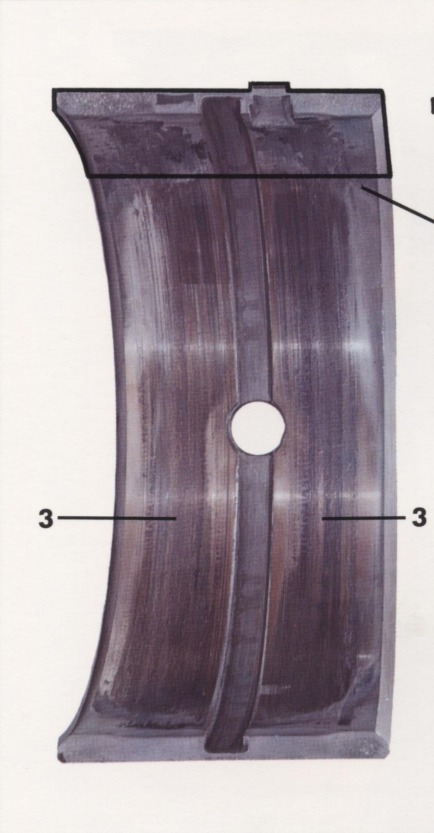
4 Material fatigue crack caused by shell flexing.

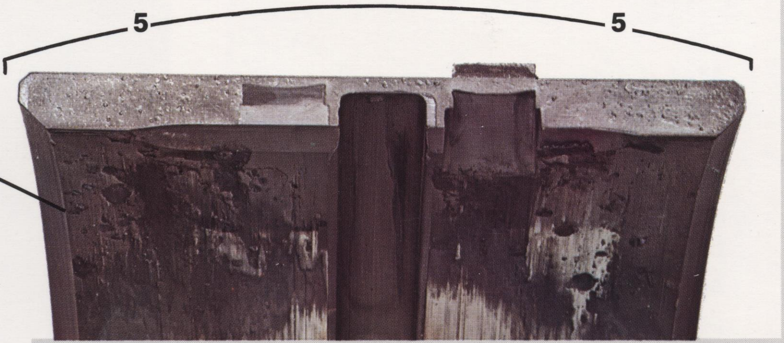
4A Dirt imprint marks on back side of steel shell.

Action:

Check bore for roughness and dirt. Clean up as necessary.

Renew bearing.





Split line metal fretting and thermal distress caused by loose bearing fit (not serviceable)

Observation:

3 Wiped (overheated) bearing metal showing thermal distress.

5 Bearing shell fretted by movement at split line.

Action:

Check additional main and connecting rod bearings for distress.

Check main and connecting rod cap bolts for proper stretch and torque. If low, retighten all, observing the proper sequence.

Bearing shell metal fretting and wear on backside caused by low stretch on bolts (not serviceable)

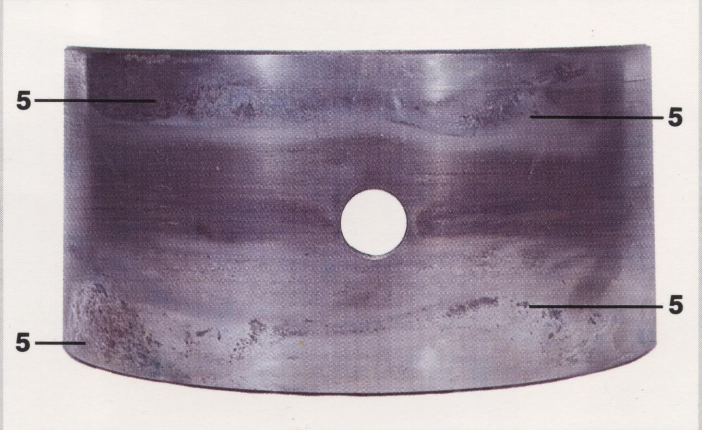
Observation:

5 Fretting distress.

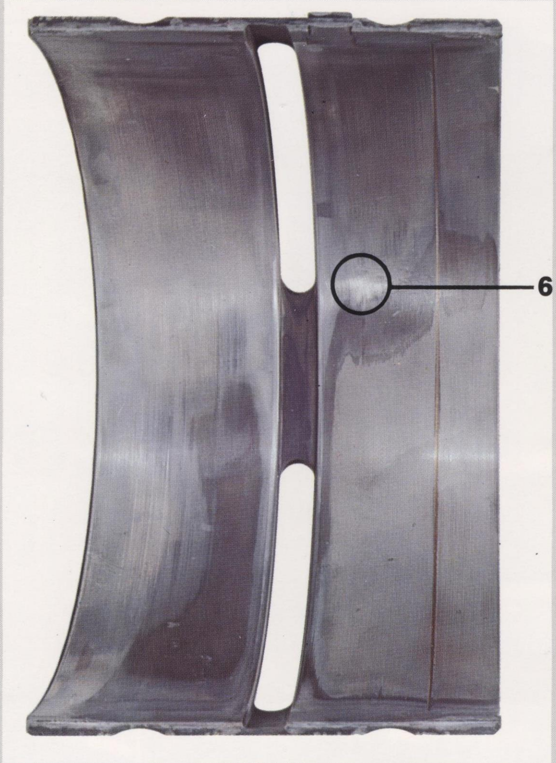
Action:

Inspect bore for roughness and dirt. Check condition at split line surfaces. Clean up as necessary.

Renew bearing.



Backside



Slight surface overlay erosion on connecting rod bearing (serviceable)

Observation:

6 Eroded area.

Action:

Condition not serious. Continue bearing operation.

If surface pitting has developed (see page 15), renew bearing.

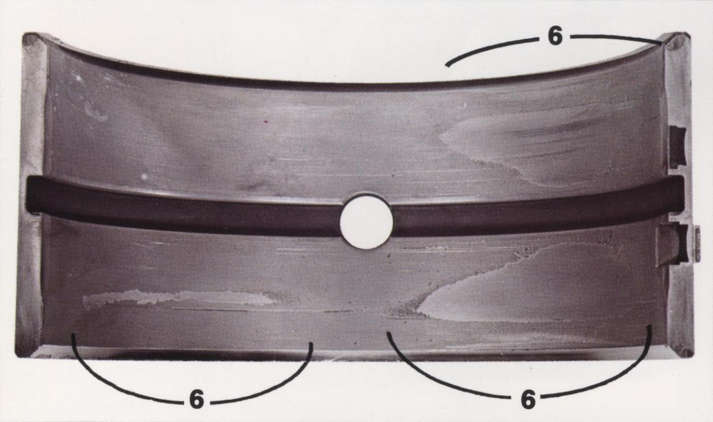
Cavitation erosion pattern commonly found on upper half of main bearings (serviceable)

Observation:

6 Eroded areas of overlay metal.

Action:

None — no effect on bearing performance.



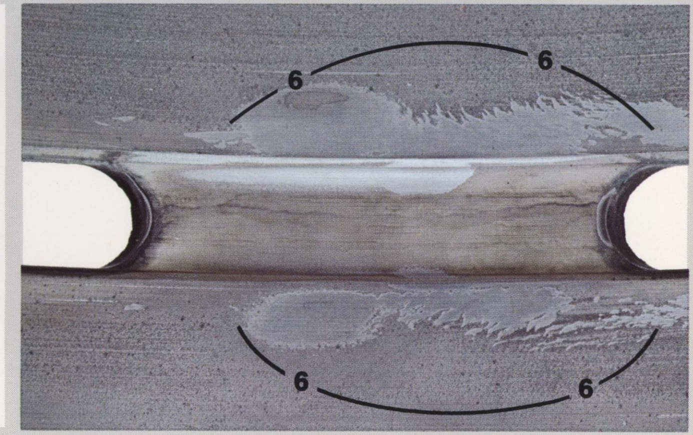
Cavitation erosion pattern commonly found on lower half of connecting rod bearings (serviceable)

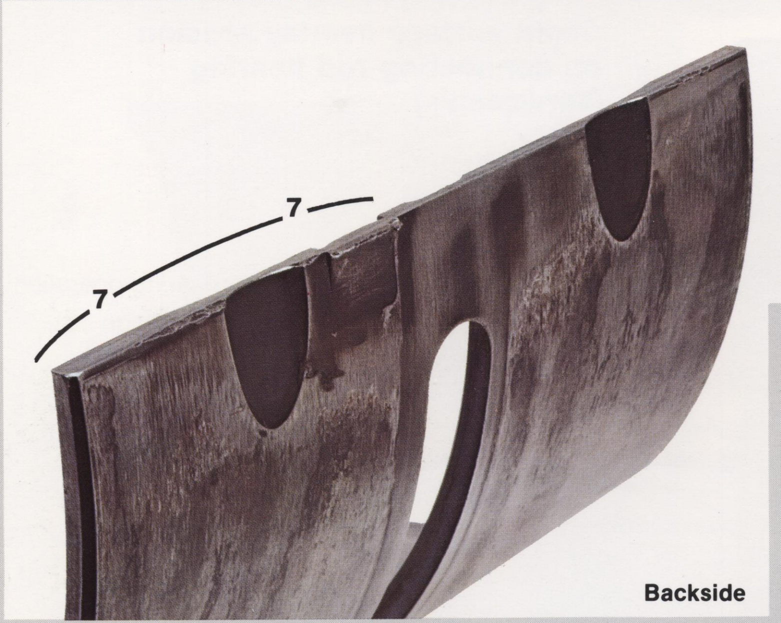
Observation:

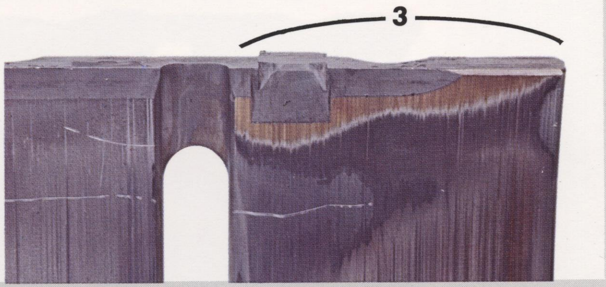
6 Eroded areas of overlay metal.

Action:

None — no effect on bearing performance.







Physical damage caused by striking bearing during installation (not serviceable)

Observation:

3 Distress on running surface due to physical damage.

7 Upset edge resulting from striking. Produces poor seating of bearing in bore.

Action:

Renew all bearings that show evidence of physical damage.

Investigate shop practices and revise as necessary to prevent installation or handling damage.

Physical damage caused by incorrect crankshaft thrust control (not serviceable)

Observation:

7 Edges of bearing shells worn and upset from taking thrust load of crankshaft. Adjacent bearing surface worn away due to surface distortion. Bent connecting rod can cause similar distress and, in addition, will produce a non-uniform wear pattern on the bearing surface.

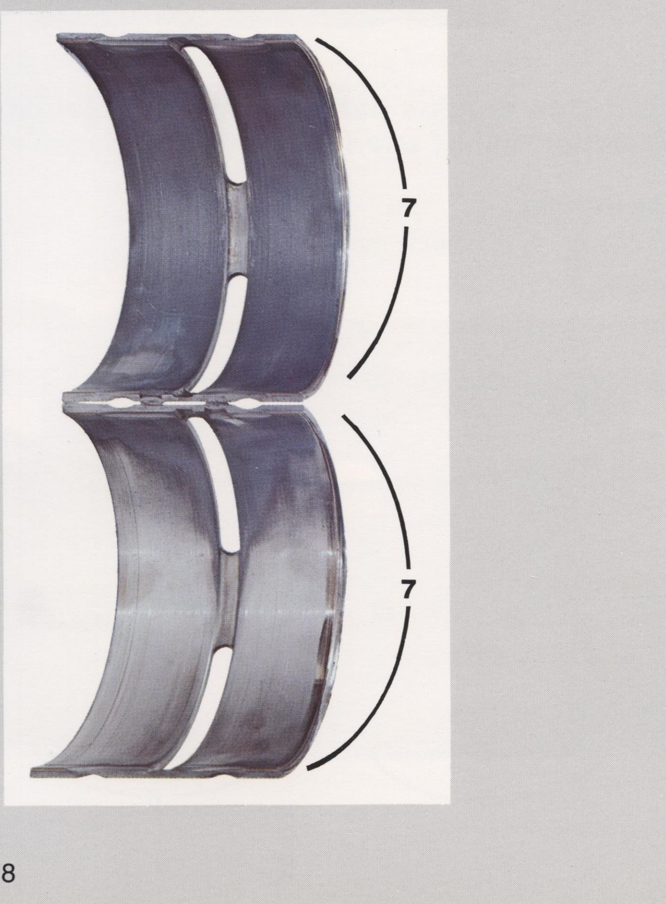
Action:

Check crankshaft thrust.

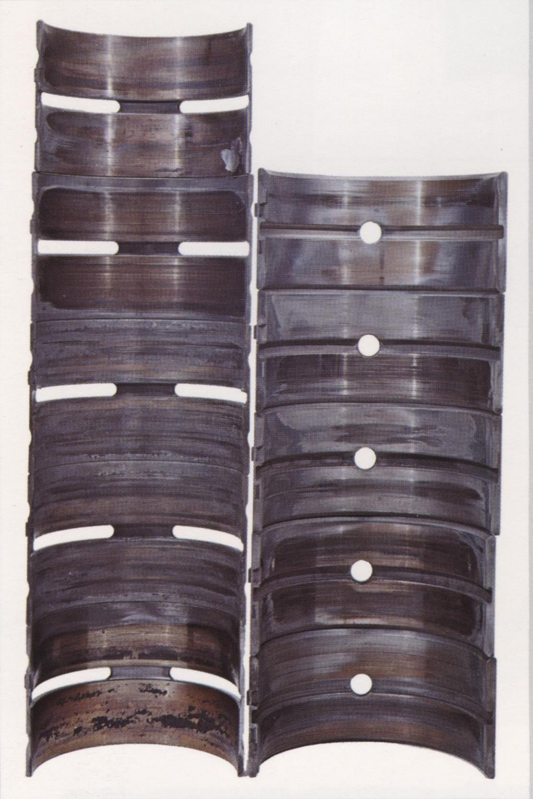
Check for bent or twisted connecting rod.

Check journal and thrust surfaces at crankshaft throw for serviceability.

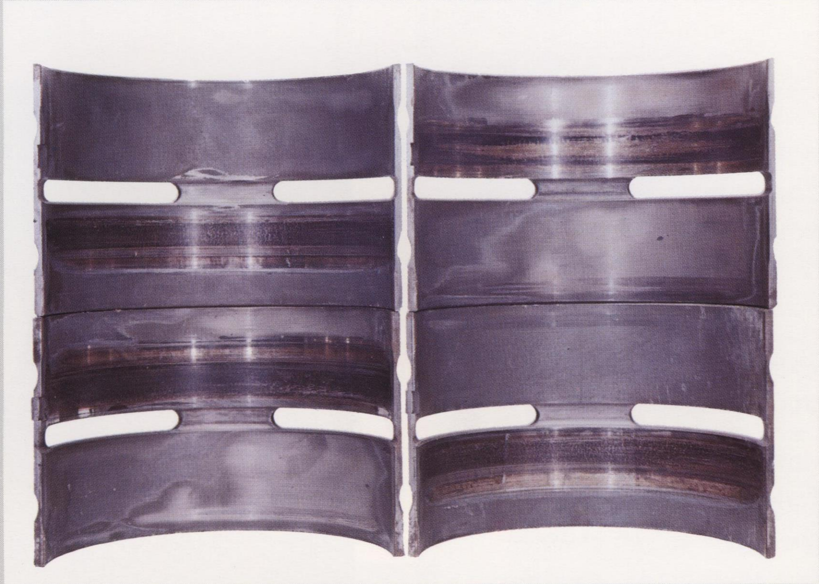
Renew bearing.



Wiped main and rod bearings typical of distress caused by engine overspeeding (not serviceable)



(Typical Bearings, Not A Set)



Observation:

Severe wiped condition is characteristic of distress resulting from overloading associated with engine overspeed.

Action:

Determine cause of overspeed.

Inspect crankshaft for journal roughness and heat checks. If no heat checks or journal scoring are found, crankshaft can be made serviceable by polishing superficial bearing metal from journal surfaces.

Renew all bearings.

Overlay wiping of main bearings due to engine overspeed. No heat discoloration is visible (serviceable)

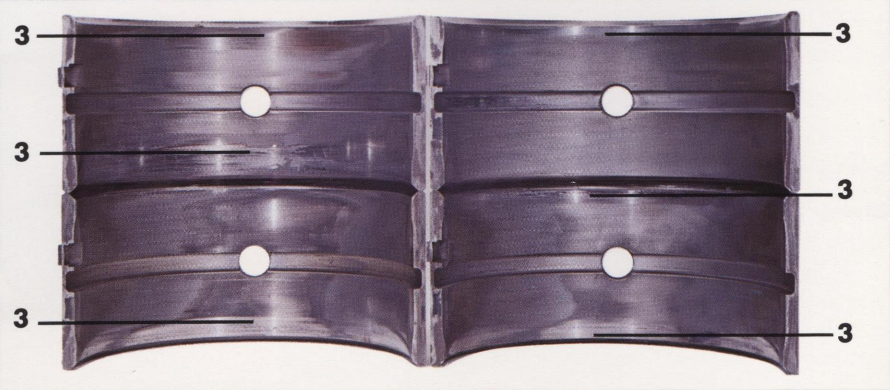
Observation:

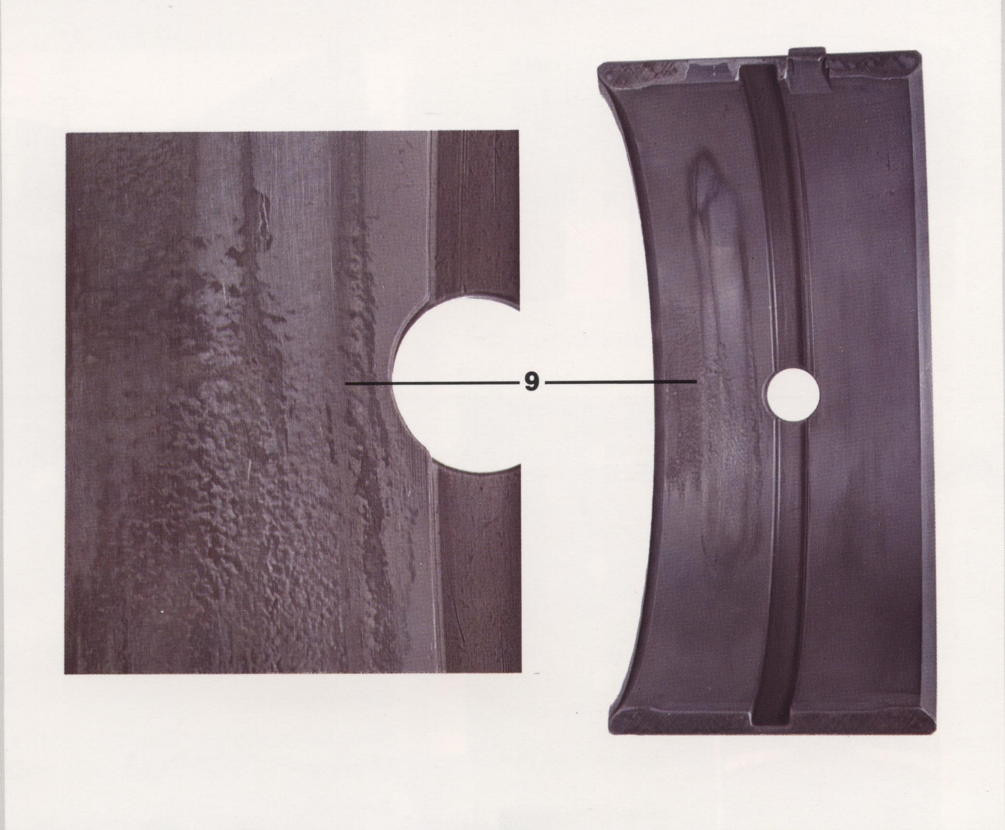
3 Typical edge loading caused by journal deflection during severe overspeed.

Action:

Determine cause of overspeed. Examine crankshaft journals for serviceability.

Check connecting rod and crankshaft thrust bearings for damage and renew if necessary. (Where heat discoloration is evident, renew the bearings).





Water damaged main bearing caused by free water contamination of the lube oil (serviceable)

Observation:

9 Eroded overlay. In severe cases of water contamination, wiping will occur.

Action:

Investigate source of water.

Spot check other connecting rod and main bearings for more serious distress.

Renew lube oil.

Water damage and wiping caused by free water contamination of lube oil (not serviceable)

Observation:

9 Overlay smear and indications of wiping of bearing metal.

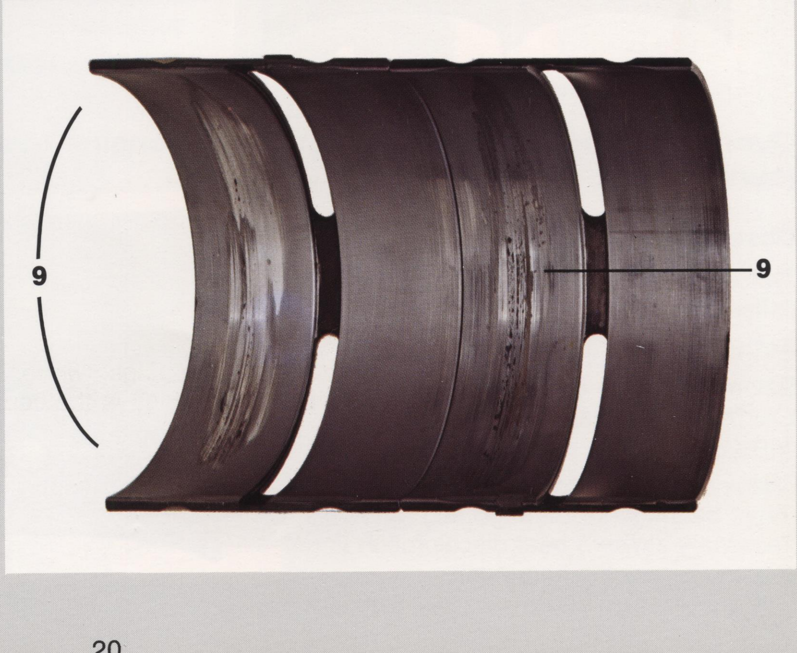
Action:

Investigate source of water.

Examine crankshaft journals for serviceability.

Renew all main and connecting rod bearings.

Renew lube oil.



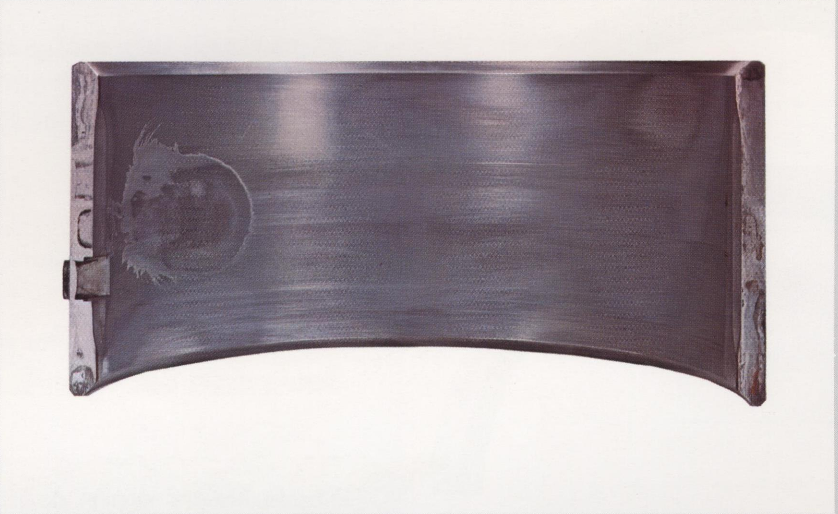
Cavitation erosion of non-grooved main bearing — lower half only (serviceable)

Observation:

6 A cavitation erosion pattern often develops in the soft overlay material. This pattern is superficial. Out of the load area, it has no effect on normal bearing life.

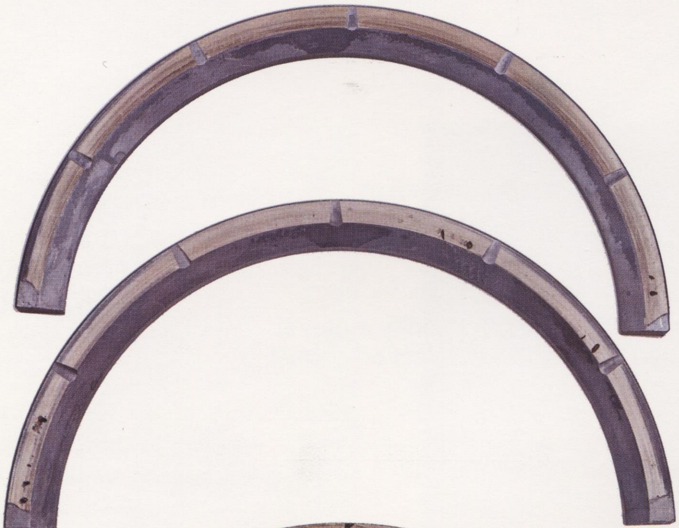
Action:

The bearing is serviceable. No action is required.



A recent design improvement, the non-grooved main bearing has been used in General Electric diesel engines since mid-1976. Eliminating the groove in the lower bearing half provides an increase in operating oil film thickness and reduced wear. This new bearing is also less sensitive to distress caused by oil degradation and should have increased life.

The bearing shown here is a pre-production example, having only one locating tab. On production bearings, two locating tabs opposite each other properly position the bearing in the cap and prevent its misapplication in the upper position.



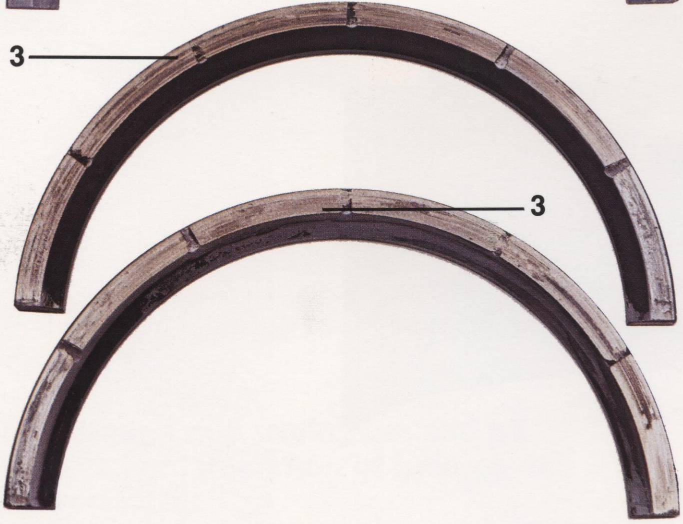
Normal thrust bearing wear with slight pitting (serviceable)

Observation:

1 Initial wear through overlay with slight pitting.

Action:

Check crankshaft thrust clearance.



Wiped and thermally distressed crankshaft thrust bearings caused by engine overspeed or loss of lubrication (not serviceable).

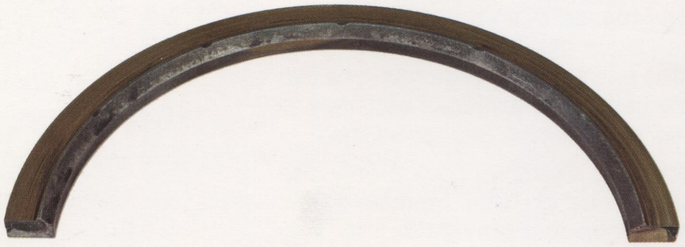
Observation:

3 Wiped due to oil film failure.

Action:

Examine thrust journals for serviceability.

Renew thrust bearings.



Excessively worn crankshaft thrust bearing caused by overextended service or poor finish on thrust journal (not serviceable).

Observation:

1 Extensive wear. Oil grooves are completely worn away. Bearing is so thin that thrust is being taken by lower bearing cap instead of thrust bearing.

Action:

Examine thrust journals for heat damage.

Inspect all main bearing caps for edge loading damage.

Renew thrust bearing.